LISTING OF CLAIMS

Claim 1

A device to measure individual or grouped cell voltages of a fuel cell stack having conductive areas to monitor fuel cell stack performance to provide diagnostic data, said device comprising:

a meter connected to individual or grouped cell conductive areas to measure the voltage and impedance of said individual or grouped cells changes in the measurement or the time response of the measurements; and

a monitor coupled to said meter to report on the performance of the fuel cell stack, such that the measurements of said individual or grouped cells are used to report on the performance of said fuel cell stack and further including a matrix array of opto isolators wherein no common ground is employed by the meter.

Claim 2 (cancel)

Claim 3

The device of Claim 1, wherein said meter instructs said monitor to report on individual cells, grouped cells, or entire fuel cell stack performance.

Claim 4

The device of Claim 55 wherein said microprocessor determines the performance of individual cells or cell groups based on the present operating current of the fuel cell stack.

Claim 5

The device of Claim 55 wherein said microprocessor determines the performance of individual cells or cell groups based on measurements of the time response of the voltage of said individual cells or cell groups during a transient response caused by a high rate of change of fuel cell stack current.

Claim 6

The device of Claim 55 wherein said microprocessor determines the performance of individual cells or cell groups based on measurements of the frequency response of the voltage of said individual cells or cell groups during a response caused by a periodic change of fuel cell stack current.

Claim 7

The device of Claim 55 wherein said microprocessor determines the performance of individual cells or cell groups based on voltage measurements of said individual cells or cell groups in addition to at least one other fuel cell system parameter.

Claim 8

The device of Claim 55 wherein said microprocessor determines the performance of individual cells or cell groups based on a logged history of voltage measurements of said individual cells or cell groups and other fuel cell system parameters.

Claim 9

The device of Claim 55 wherein said microprocessor instructs a current load in communication with said microprocessor, electrically connected to said fuel cell stack, to provide a current load to the fuel cell stack in order to measure the voltage of individual cells or cell groups at various fuel cell stack-operating currents.

Claim 10

The device of Claim 9, wherein said current load is a battery charger coupled to said microprocessor.

Claim 11

The device of Claim 5, wherein said microprocessor instructs a current load, electrically connected to said fuel cell stack, to modulate the current of the fuel cell stack in order to measure the transient response of the voltage of individual cells or cell groups.

Claim 12

The device of Claim 6, wherein said microprocessor instructs a current load, electrically connected to said fuel cell stack, to modulate the current of the fuel cell stack in order to measure the frequency response of the voltage of individual cells or cell groups.

Claim 13

The device of Claim 55 wherein said microprocessor measures the contact resistance between electrical contacts of said contact assembly and said conductive areas of said individual cells or cell groups, to determine the condition of an poor electrical connection and potential false voltage reading.

Claim 14 (cancel)

Claim 15

The device of Claim 1, wherein said meter provides electrical isolation between individual cells or grouped cells connected to and external electrical connections of said meter.

Claim 16

The device of Claim 55 wherein said meter further includes:

an electrical connection from said multiplexor output to allow connection of the multiplexor output signal to external measurement devices.

Claim 17 (cancel)

Claim 18

The device of Claim 1, wherein said meter includes:

an alarm or an electrical connection for an external alarm device.

Claim 19

The device of Claim 1, wherein said monitor includes:

a personal computer running interface and monitoring software.

Claim 20

The device of Claim 1, wherein said monitor:

displays present, minimum, maximum, and average voltages or impedance of individual cells or grouped cells or of performance parameters based on these voltages.

Claim 21

The device of Claim 1, wherein said monitor:

provides a strip chart or graphical trend of voltages of individual cells or grouped cells or of performance parameters based on these voltages.

Claim 22

The device of Claim 1, wherein said monitor:

logs or stores a history of voltages of individual cells or grouped cells or of performance parameters based on these voltages.

Claim 23

The device of Claim 1, wherein said monitor:

displays impedance models based on voltages of individual cells or grouped.

Claim 24

The device of Claim 1, wherein said monitor:

provides automated sequencing and data collection of performance tests.

Claim 25

A device to measure individual or grouped cell voltages of a fuel cell stack having conductive areas to monitor fuel cell stack performance to adjust fuel cell system operating parameters to optimize fuel cell stack performance and to maintain safe operating conditions:

a meter connected to individual or grouped cell conductive areas to measure the voltage or impedance of said individual or grouped cells and further including a matrix array of opto isolators to eliminate the need for a common ground; and

a controller coupled to with or comprised in part of said meter to adjust fuel cell system operating parameters,

such that the measurements of said individual or grouped cells are used to adjust fuel cell system operating parameters to optimize fuel cell stack performance and to maintain safe operating conditions.

Claim 26 (cancel)

Claim 27

The device of Claim 25, wherein said meter instructs said controller to adjust fuel cell system operating parameters to optimize fuel cell stack performance and to maintain safe operating conditions.

Claim 28

The device of Claim 25, wherein said meter instructs said controller to perform a fuel cell system shutdown procedure to avoid unsafe operating conditions or fuel cell stack damage.

Claim 29

The device of Claim 56, wherein said microprocessor determines the performance of individual cells or cell groups based on the present operating current of the fuel cell stack.

Claim 30

The device of Claim 58 wherein said microprocessor determines the performance of individual cells or cell groups based on measurements of the time response of the voltage of said individual cells or cell groups during a transient response caused by a high rate of change of fuel cell stack current.

Claim 31

The device of Claim 58 wherein said microprocessor determines the performance of individual cells or cell groups based on measurements of the frequency response of the voltage of said individual cells or cell groups during a response caused by a periodic change of fuel cell stack current.

Claim 32

The device of Claim 56, wherein said microprocessor determines the performance of individual cells or cell groups based on voltage measurements of said individual cells or cell groups in addition to at least one other fuel cell system parameter.

Claim 33

The device of Claim 58 wherein said microprocessor determines:

the performance of individual cells or cell groups based on voltage measurements of said individual cells or cell groups in addition to at least one other fuel cell system parameter; and,

the performance of individual cells or cell groups based on a logged history of voltage measurements of said individual cells or cell groups and other fuel cell system parameters.

Claim 34

The device of Claim 58 wherein said microprocessor instructs a current load in communication with said microprocessor, electrically connected to said fuel cell stack, to provide a current load to the fuel cell stack in order to measure the voltage of individual cells or cell groups at various fuel cell stack-operating currents.

Claim 35

The device of Claim 34, wherein said current load is a battery charger in communication with said microprocessor.

Claim 36

The device of Claim 30, wherein said microprocessor instructs a current load, electrically connected to said fuel cell stack, to modulate the current of the fuel cell stack in order to measure the transient response of the voltage of individual cells or cell groups.

Claim 37

The device of Claim 31, wherein said microprocessor instructs a current load, electrically connected to said fuel cell stack, to modulate the current of the fuel cell stack in order to measure the frequency response of the voltage of individual cells or cell groups

Claim 38

The device of Claim 58 wherein said microprocessor measures the contact resistance between electrical contacts, of said contact assembly and said conductive areas of said individual cells or cell groups, to determine the condition of an poor electrical connection and potential false voltage reading

Claim 39

The device of Claim 58 further including:

one or more additional meters to allow the measurement of voltages of additional individual cells or grouped cells connected to said meter.

Claim 40

The device of Claim 25, wherein said meter provides electrical isolation including opto isolators between individual cells or grouped cells connected thereto and external electrical connections of said meter

Claim 41

The device of Claim 58, wherein said meter further includes an electrical connection from said multiplexor output to allow connection of the multiplexor output signal to external measurement devices.

Claim 42

The device of Claim 25, wherein said meter further includes a voltage or current excitation source in electrical connection with said multiplexor to provide for a method to allow compatibility with temperature sensing devices to allow multiple point temperature measurements.

Claim 43

The device of Claim 25, wherein said meter further includes an alarm or an electrical connection for an external alarm device.

Claim 44

The device of Claim 25, wherein said controller controls at least one control parameter of the fuel cell system.

Claim 45

The device of Claim 44, wherein said controller modulates the flow of at least one of the reactant gases entering the fuel cell stack.

Claim 46

The device of Claim 44, wherein said controller modulates the humidification of at least one of the reactant gases entering the fuel cell stack.

Claim 47

The device of Claim 44, wherein said controller modulates the temperature of at least one of the reactant gases entering the fuel cell stack.

Claim 48

The device of Claim 44, wherein said controller modulates the temperature of the fuel cell stack.

Claim 49

The device of Claim 44, further including reactant gases and wherein said controller modulates or limits the output load current of the fuel cell stack.

Claim 50

The device of Claim 44, wherein said controller modulates control parameters according to individual or grouped cell performance parameters.

Claim 51

The device of Claim 25, further including switches wherein said controller instructs switches electrically connected to individual cells or cell groups to isolate said individual cells or cell groups and provide a current bypass.

Claim 52

The device of Claim 55 wherein said contact assembly a plurality of electrical connections positioned at a plurality of points around the perimeter of said individual or grouped cells.

Claim 53

The device of Claim 52, wherein said meter interprets differences in voltages, measured at a plurality of points around the perimeter of said individual or grouped cells, to provide a determination of a disproportionate current density distribution across the plane of individual cells.

Claim 54

The device of Claim 1, further includes batteries or super-capacitors coupled to said cells

Claim 55

A device to measure individual or grouped cell voltages of a fuel cell stack having conductive areas to monitor fuel cell stack performance to provide diagnostic data, said device comprising:

a meter connected to individual or grouped cell conductive areas to measure the voltage of said individual or grouped cells; and

a monitor coupled to said meter to report on the performance of the fuel cell stack such that the measurements of said individual or grouped cells are used to report on the performance of said fuel cell stack wherein said meter further includes

a contact assembly associated with said individual or grouped cell conductive areas, wherein said contact assembly is electrically connected to said individual or grouped cell conductive areas; and

a multiplexer to switch between electrical connections of individual or grouped cells establishing an electrical signal path from an individual cell or group of cells; and,

an attenuator/amplifier to attenuate or amplify said electrical signal from said multiplexer; and,

a converter to convert the electrical signal from said attenuator/amplifier from an analog signal to a digital signal; and,

a microprocessor to read and interpret said digital signal, and

wherein said microprocessor communicates the measurement value or any diagnostic data based on said measurement to said monitor.

Claim 56

The device of Claim 1 further including:

one or more additional meters connected to said meter to allow the measurement of voltages of additional individual cells or grouped cells further including

a meter connected to individual or grouped cell conductive areas to measure the voltage of said individual or grouped cells; and

a monitor coupled to said meter to report on the performance of the fuel cell stack such that the measurements of said individual or grouped cells are used to report on the performance of said fuel cell stack.

Claim 57

A device to measure individual or grouped cell voltages of a fuel cell stack having conductive areas to monitor fuel cell stack performance to provide diagnostic data wherein said meter further includes:

a voltage or current excitation source in electrical connection with said multiplexer and temperature sensing devices to provide for a method to allow compatibility with temperature sensing devices to allow multiple point temperature measurements

wherein said meter is connected to individual or grouped cell conductive areas to measure the voltage of said individual or grouped cells; and

a monitor coupled to said meter to report on the performance of the fuel cell stack such that the measurements of said individual or grouped cells are used to report on the performance of said fuel cell stack.

Claim 58

A device to measure individual or grouped cell voltages of a fuel cell stack having conductive areas to monitor fuel cell stack performance to adjust fuel cell system operating parameters to optimize fuel cell stack performance and to maintain safe operating conditions:

a meter connected to individual or grouped cell conductive areas to measure the voltage of said individual or grouped cells; and

a controller coupled to with or comprised in part of said meter to adjust fuel cell system operating parameters,

such that the measurements of said individual or grouped cells are used to adjust fuel cell system operating parameters to optimize fuel cell stack performance and to maintain safe operating conditions;

a contact assembly associated with said individual or grouped cell conductive areas, wherein said contact assembly is electrically connected to said individual or grouped cell conductive areas; and,

a multiplexer to switch between electrical connections of individual or grouped cells establishing an electrical signal path from an individual cell or group of cells; and,

an attenuator/amplifier to attenuate or amplify said electrical signal from said multiplexer; and,

a converter to convert the electrical signal from said attenuator/amplifier from an analog signal to a digital signal; and,

a microprocessor to read and interpret said digital signal,

wherein said microprocessor communicates the measurement value or any evaluations based on said measurement to said controller.

Claim 59 (cancel)